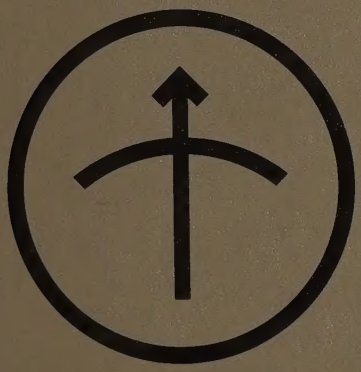
MODEL M-234
ATTENUATOR

Operating INSTRUCTIONS



MEASUREMENTS
A McGRAW-EDISON DIVISION
BOONTON NEW JERSEY

MODEL M-234
ATTENUATOR

Operating INSTRUCTIONS

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APPLICATION OF M-234 ATTENUATOR

The M-234 is a coaxial attenuator of the mutual inductance type operating on the transverse magnetic field as a waveguide below cut-off.

If care is exercised to minimize E_o input to the attenuator, the design is capable of operation satisfactorily between 2 and approximately 1,000 megacycles. It may be necessary to concentrate the input magnetic flux, in order to obtain sufficient voltage at the lower end of this frequency range.

The calibrating rheostat is adjusted prior to shipment for 100 K MICROVOLTS line to ground, when the output meter is set to the red line. This value will only be obtained when the type N output fittings are terminated in 50 ohms to ground. In order to obtain other values of output, it is then necessary to set the fiducial ring opposite 100 K on the inner MICROVOLT dial, and then reduce the output by means of the MICROVOLT dial to the desired value as indicated on it.

Terminated connection cables can be used with the M-234 attenuator such as our 80ZH4 which is regularly supplied as an accessory to the Model 80. Suitable pads can be supplied on order for matching other impedance levels.

Care must be exercised not to apply more than 1 volt to the 1N21 silicon crystal used to calibrate the attenuator. If this crystal is overloaded, it will be permanently damaged and require replacement.

A-4551-B

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Because this type attenuator is driven by a magnetic field, it is impossible to specify the input impedance in terms of ohms. The Model M-234 Attenuator is designed to operate on the principle of the attenuation of a transverse magnetic field inside a metallic tube, small compared to wave length. (Sometimes called a wave-guide below cut off).

When properly matched by a suitable driving coil, the initial or minimum insertion loss approximates 20 d.b. It is necessary to concentrate the transverse magnetic field at the input of the attenuator and this is most readily done by means of a tuned circuit. A rather high "C" tuned circuit will produce a strong magnetic field which is desirable for obtaining the lowest minimum insertion loss.

If sufficient power is available, an untuned coupling loop driven by a cathode follower may be useful for operation over a broader frequency range than that available from a single tuned circuit.

Whatever the type of coil used to drive the attenuator, it should be of small physical dimensions and located so as to concentrate its magnetic field transversely across the attenuator tube. The coil should be oriented for maximum output, i.e., its axis parallel to that of the attenuator pickup coil. The driving coil must be shielded carefully to prevent direct radiation from by-passing the attenuator to the receiver under test.

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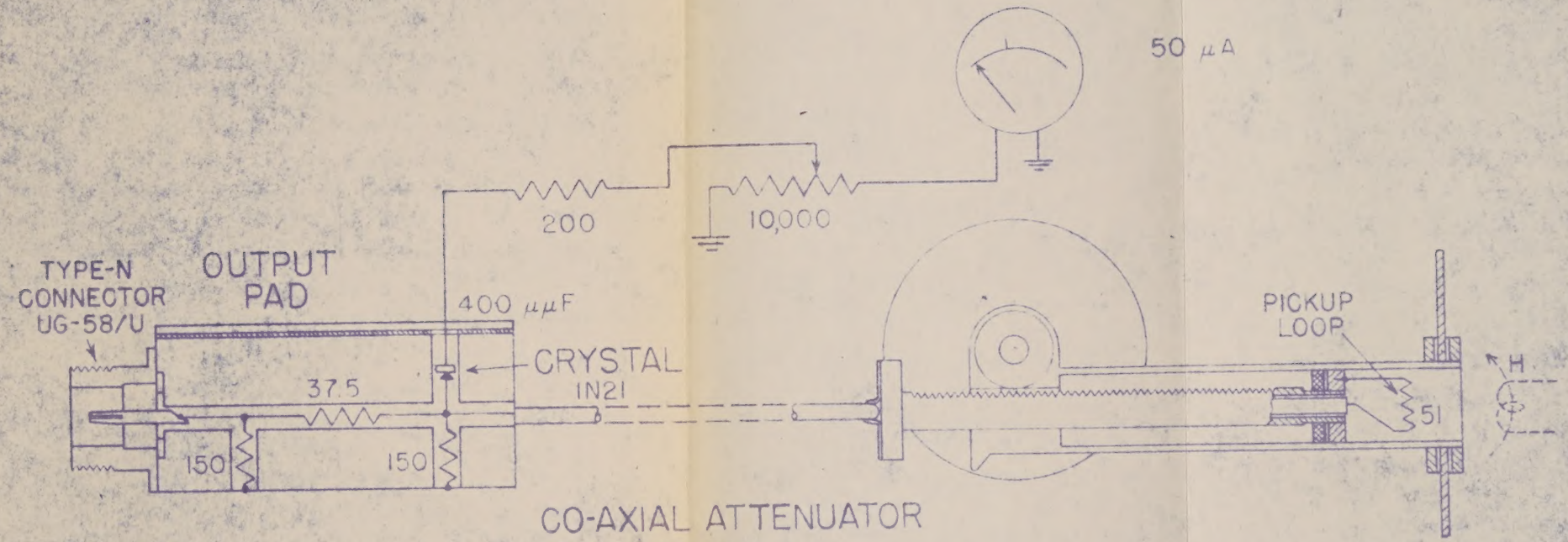
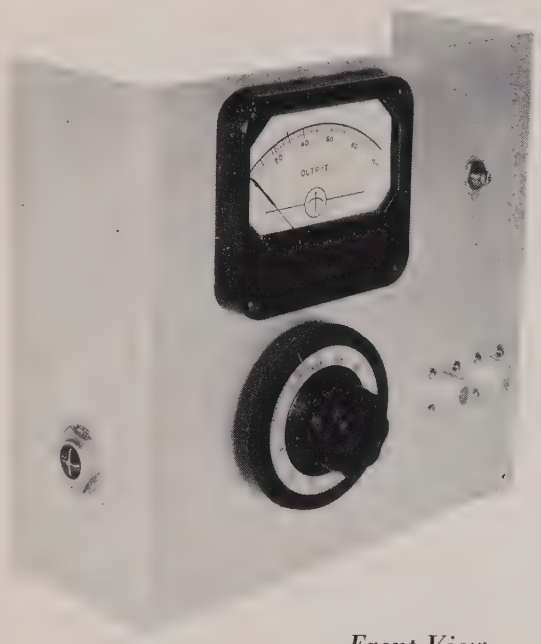


CO-AXIAL ATTENUATOR
M-234

R. F. ATTENUATOR
Model M-235



Front View

THE M-235 is a balanced attenuator of the mutual inductance type operating on the transverse magnetic field as a wave-guide below cut-off. Balanced output is secured by operating two co-axial outputs back to back out of phase. A rack and split gear drive assure long life and smooth operation. This attenuator is well suited to many specialized applications such as: FM and television receiver production test equipment, transmission line test sets, antenna test sets, etc.

SPECIFICATIONS:

OUTPUT RANGE:
0.3 to 100,000 microvolts.

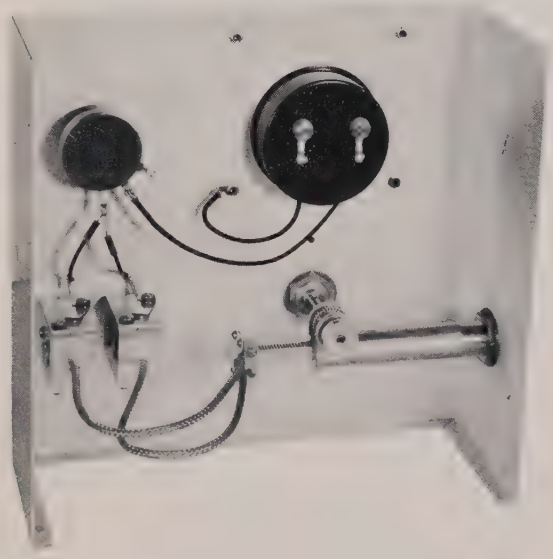
OUTPUT CALIBRATION:
Calibrated at 100,000 microvolts (line to line) across terminated output by 1N21 crystals.

OUTPUT IMPEDANCE:
100 ohms line to line or 50 ohms line to ground; two type N connectors.

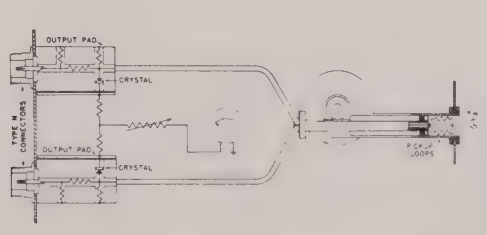
FREQUENCY RANGE:
Approximately 2 to 300 megacycles.

DIMENSIONS:
10⅛" wide, 9⅝" high, 5½" deep incl. knob.

WEIGHT:
Approximately 3¾ pounds.



Rear View



BALANCED ATTENUATOR

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R. F. ATTENUATOR
Model M-234

Front View

THE M-234 is a co-axial attenuator of the mutual inductance type operating on the transverse magnetic field as a wave-guide below cut-off. A rack and split gear drive assure long life and smooth operation. This attenuator is well suited to many specialized applications such as: AM, FM, and television receiver production test equipment, stage gain test sets, filter test sets, etc.

SPECIFICATIONS:

OUTPUT RANGE:
0.3 to 100,000 microvolts.

OUTPUT CALIBRATION:
Calibrated at 100,000 microvolts across terminated output by 1N21 crystal.

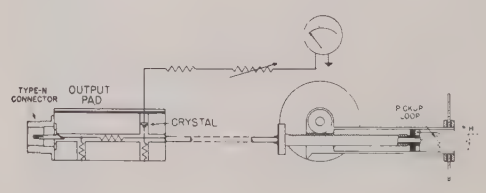
OUTPUT IMPEDANCE:
50 ohms; type N connector.

FREQUENCY RANGE:
Approximately 2 to 1000 megacycles.

DIMENSIONS:
Width 10⅛", Height 9⅝", Depth 5½" incl. knobs.

WEIGHT:
Approximately 3½ lbs.

Rear View



CO-AXIAL ATTENUATOR

MEASUREMENTS CORPORATION

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MEASUREMENTS NOTES

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SIGNAL GENERATORS AND THE IMPORTANCE OF MATCHED IMPEDANCES

Users of Signal Generators often question the true value of voltage developed across the input of the receiver under test. They are also confused when the apparent sensitivity appears to be a function of the generator with which the measurement is made.

Measurements made with different generators can usually be correlated if consideration is given to: (1) output impedance of the generator, (2) possibility of standing waves on the output cable, (3) effect of load impedance, (4) resonance in leads used to connect generator to load.

The output circuit of the modern signal generator is designed for use with a transmission line output cable. That is, the output terminals, instead of appearing on the front panel, are placed at the extremity of a coaxial cable thereby permitting the use of extremely short leads between generator and load. This cable functions as a transmission line and should be properly terminated at both ends for optimum performance.

Signal Generators are calibrated in terms of voltage appearing across the terminals of the output cable terminated by its characteristic impedance. The following examples will illustrate the errors that may be introduced by line characteristics and load impedances.

RESISTIVE ATTENUATORS

Figure 1 represents the equivalent circuit of a signal generator with step-type resistor attenuator and terminated output cable.

R_O = Terminating resistor equal to characteristic impedance of output cable.
Z_A = Impedance of step attenuator
Z_{SG} = Impedance seen looking into output terminals is referred to as the "output impedance of the generator."
Z_L = External load impedance
E_{SG} = Indicated open circuit voltage across R_O.
E_L = Voltage developed across load impedance.

$$E_L = E_{SG} \frac{Z_L}{Z_{SG} + Z_L}$$

When $Z_L >> Z_{SG}$, $E_L = E_{SG}$. When Z_L is comparable in magnitude to Z_{SG}, E_L will be less than E_{SG}.

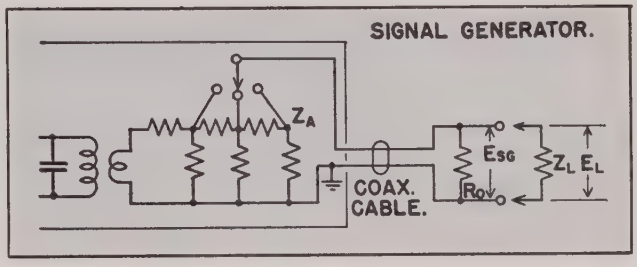

FIGURE 1

It should be noted that when $Z_A = R_O$ the cable is properly terminated at both ends and the output impedance equals $\frac{R_O}{2}$ and will be substantially constant and independent of frequency. When Z_A does not equal R_O the output impedance will vary with increasing frequency as the cable approaches a quarter wavelength.

MUTUAL INDUCTANCE ATTENUATORS

Let us now consider a mutual inductance attenuator, Figure 2.

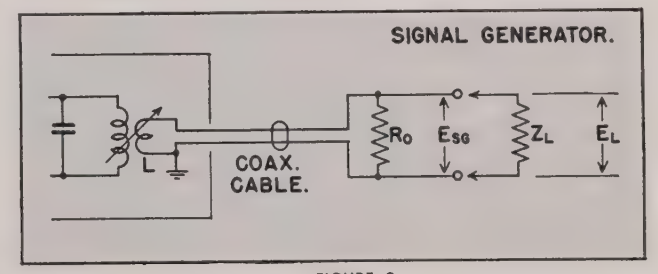

FIGURE 2

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E_{SG} = Indicated open-circuit voltage across R_O.

Z_L = External load impedance.

Z_{SG} = Impedance seen looking into output terminals.

R_O = Terminating resistor equal to characteristic impedance of output cable.

At low frequencies the reactance of the coupling coil L is usually negligible and Z_{SG} is very low. As the frequency is increased, however, the reactance of the cable, as viewed from the output terminals increases until the cable becomes a quarter wavelength line and theoretically appears as an open circuit. The output impedance then equals R_O.

As in the previous case $E_L = E_{SG} \frac{Z_L}{Z_{SG} + Z_L}$. At the lower frequencies Z_{SG} is very small and for a given value of Z_L loading effect is not as noticeable as at the higher frequencies.

In order to overcome the effect of varying output impedance it is customary to terminate the output cable at both ends. This is accomplished at the generator end by means of an impedance matching pad which isolates the coupling loop from the external cable. The pad is usually designed for a 2:1 voltage loss and the correction indicated by a "pad" fiducial mark on the attenuator dial. The output impedance of the generator is now Ro/2 and the voltage across the output terminal is Esg/2.

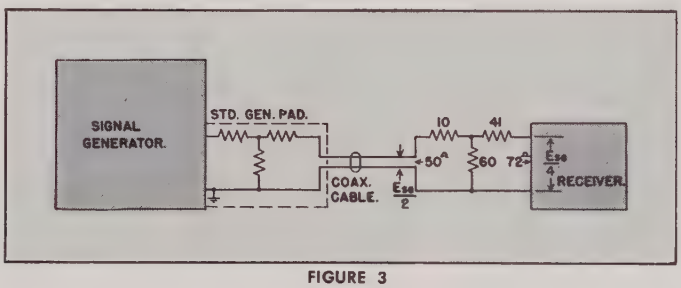

FIGURE 3

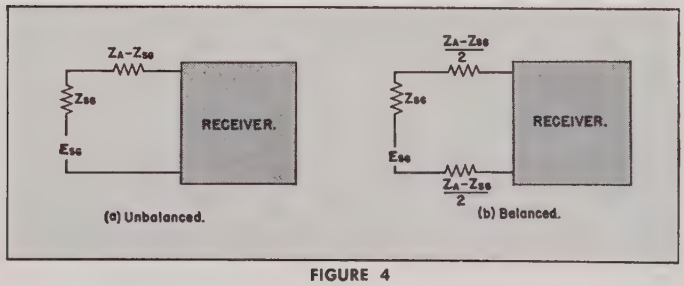

FIGURE 4

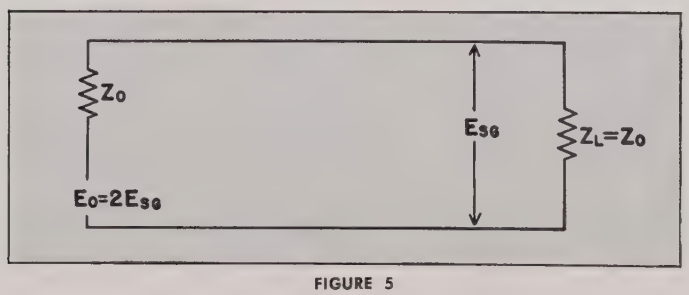

FIGURE 5

FREQUENCY EFFECTS

As the frequency is increased resonance effects will occur with even the shortest possible leads between the output terminals and Z_L. It then becomes desirable to design the input circuit of the equipment under test to match the characteristic impedance of the cable, thereby eliminating R_O. Whenever the input circuit of the equipment is designed to match a line of different impedance from that supplied with the generator, a suitable pad can be designed to match the generator to the new line.

It is often possible to improvise suitable resistance pads from non-inductive carbon resistors using the shortest possible leads. Simple T pads can be computed from hand book formulas.

They can be calculated on the basis of a simple voltage attenuation ratio such as 2:1 making it convenient to apply a corresponding correction factor to the indicated voltage.

Figure 3 shows an example of a T pad used to match a 50-ohm cable to a 72-ohm receiver.

The resistor values given have been computed to match 50 to 72 ohms with a 2:1 drop in voltage (corresponding to 5.7:1 power ratio).

USE OF DUMMY ANTENNAS

Allowance should be made for the output impedance of the signal generator when testing a receiver through a dummy antenna. Recommended methods for connecting the generator to the receiver are shown in Figure 4.

E_{SG} = Indicated voltage of signal generator
Z_{SG} = Output impedance of signal generator (when properly terminated)
Z_A = Specified antenna impedance.

The output circuit of most signal generators is unbalanced to ground and when the input circuit of the receiver is also unbalanced, the connection shown in Figure 4a is satisfactory. When the receiver input is balanced to ground and the value of $Z_A - Z_{SG}$ is considerably higher than the internal impedance of the generator, the circuit of Figure 4b can be used. The effect of unbalance, usually negligible, may be checked by reversing the connections at the receiver and averaging the two readings.

For measurements at very high frequencies, special transformers for matching unbalanced to balanced lines are available. These are especially recommended for use when testing FM and TV receivers.

For some purposes it is desirable to consider the applied voltage as being supplied by a source impedance Z_O as shown in Figure 5. Then the driving voltage E_O may be considered as equal to twice the indicated voltage, E_{SG}. This concept of driving voltage is convenient when determining the noise factor of receivers. It is also useful for calibrating field strength measuring receivers in terms of the voltage induced in the antenna.

PRECAUTIONS

The signal generator is capable of making accurate measurements when used correctly. A careful analysis of test connections should always be made and the limitations of the generator considered. A pad should be used whenever possible and output cables should always work into a matched load for greatest accuracy of measurement. Where this is not possible, measurement data should be corrected as has been shown above.

Attenuators offer low impedance to power-line voltages. Particular care should be observed when testing AC-DC receivers to isolate test leads with capacitors to avoid damage to the attenuator circuits.

SUMMARY OF MEASUREMENTS NOTES

Number One – "THE ELIMINATION OF TELEVISION INTERFERENCE WITH THE AID OF THE MODEL 59 MEGACYCLE METER". Interesting data on the design and construction of interference rejection traps, FM band-elimination filters and high-pass filters.

Number Two – "MEASUREMENT OF RECEIVER IMPULSE NOISE SUSCEPTIBILITY". Presented as an aid to industry in making measurements of receiver susceptibility to ignition interference.

Number Three – "TELEVISION TRANSIENT RESPONSE MEASUREMENT". The use of the square wave generator in the measurement of the transient response characteristics of television receivers.

Number Four – "TRANSMISSION LINE FAULT LOCATION WITH THE MEGACYCLE METER". Using the Model 59 as a simple, portable instrument for the convenient measurement of the distance to faults on transmission lines.

Number Five – "QUARTZ CRYSTAL MEASUREMENTS WITH THE MEGACYCLE METER". How the Model 59 Megacycle Meter is employed for measuring the electrical characteristics of Quartz Crystals and checking crystal frequencies.

Number Six – "TRANSIENT MEASUREMENTS WITH THE MODEL 71 SQUARE WAVE GENERATOR". A review of some applications of the square-wave testing technique with the Model 71 Square Wave Generator.

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MEASUREMENTS "FAMOUS FIRSTS" in Laboratory Standards

1939 MODEL 54 STANDARD SIGNAL GENERATOR—Frequency range of 100 Kc. to 20 Mc. The first commercial signal generator with built-in tuning motor.

MODEL 65-B STANDARD SIGNAL GENERATOR—This instrument replaced the Model 54 and incorporated many new features including an extended frequency range of 75 Kc. to 30 Mc.

1940 MODEL 58 UHF RADIO NOISE AND FIELD STRENGTH METER—With a frequency coverage from 15 Mc. to 150 Mc. This instrument filled a long wanted need for a field strength meter usable above 20 Mc.

MODEL 79-B PULSE GENERATOR—The first commercially-built pulse generator.

1941 MODEL 75 STANDARD SIGNAL GENERATOR—The first generator to meet the need for an instrument covering the I.F. and carrier ranges of high frequency receivers. Frequency range, 50 Mc. to 400 Mc.

1942 SPECIALIZED TEST EQUIPMENT FOR THE ARMED SERVICES.

1943 MODEL 84 STANDARD SIGNAL GENERATOR—A precision instrument in the frequency range from 300 Mc. to 1000 Mc. The first UHF signal generator to include a self-contained pulse modulator.

1944 MODEL 80 STANDARD SIGNAL GENERATOR—With an output metering system that was an innovation in the field of measuring equipment. This signal generator, with a frequency range of 2 Mc. to 400 Mc. replaced the Model 75 and has become a standard test instrument for many manufacturers of electronic equipment.

1945 MODEL 78-FM STANDARD SIGNAL GENERATOR—The first instrument to meet the demand for a moderately priced frequency modulated signal generator to cover the range of 86 Mc. to 108 Mc.

1946 MODEL 67 PEAK VOLTMETER—The first electronic peak voltmeter to be produced commercially. This new voltmeter overcame the limitations of copper oxide meters and electronic voltmeters of the r.m.s. type.

1947 MODEL 90 TELEVISION SIGNAL GENERATOR—The first commercial wide-band, wide-range standard signal generator ever developed to meet the most exacting standards required for high definition televison use.

1948 MODEL 59 MEGACYCLE METER—The familiar grid-dip meter, but its new design, wide frequency coverage of 2.2 Mc. to 400 Mc. and many other important features make it the first commercial instrument of its type to be suitable for laboratory use.

1949 MODEL 82 STANDARD SIGNAL GENERATOR—Providing the extremely wide frequency coverage of 20 cycles to 50 megacycles. An improved mutual inductance type attenuator used in conjunction with the 80 Kc. to 50 Mc. oscillator is one of the many new features.

MODEL 112 U.H.F. OSCILLATOR—Designed for the many applications in ultra-high frequency engineering that require a signal source having a high degree of frequency accuracy and stability. Range: 300 Mc. to 1000 Mc.

1950 MODEL 111 CRYSTAL CALIBRATOR—A calibrator that not only provides a test signal of crystal-controlled frequency but also has a self-contained receiver of 2 microwatts sensitivity.

1951 MODEL 31 INTERMODULATION METER—With completely self-contained test signal generator, analyzer, voltmeter and power supply. Model 31 aids in obtaining peak performance from audio systems, AM and FM receivers and transmitters.

1952 MODEL 84 TV STANDARD SIGNAL GENERATOR—With a frequency range of 300-1000 Mc., this versatile new instrument is the first of its kind designed for the UHF television field.

1953 MODEL 59-UHF MEGACYCLE METER—With a frequency range of 430 to 940 megacycles, the first grid-dip meter to cover this range in a single band and to provide laboratory instrument performance.

1954 FM STANDARD SIGNAL GENERATOR. Designed, originally, for Military service, the commercial model embodies performance far surpassing that of equipment presently available.
Wide modulation frequency response, extremely low distortion, and high stability make this instrument useful for critical FM, multiplex, and telemetering applications.

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